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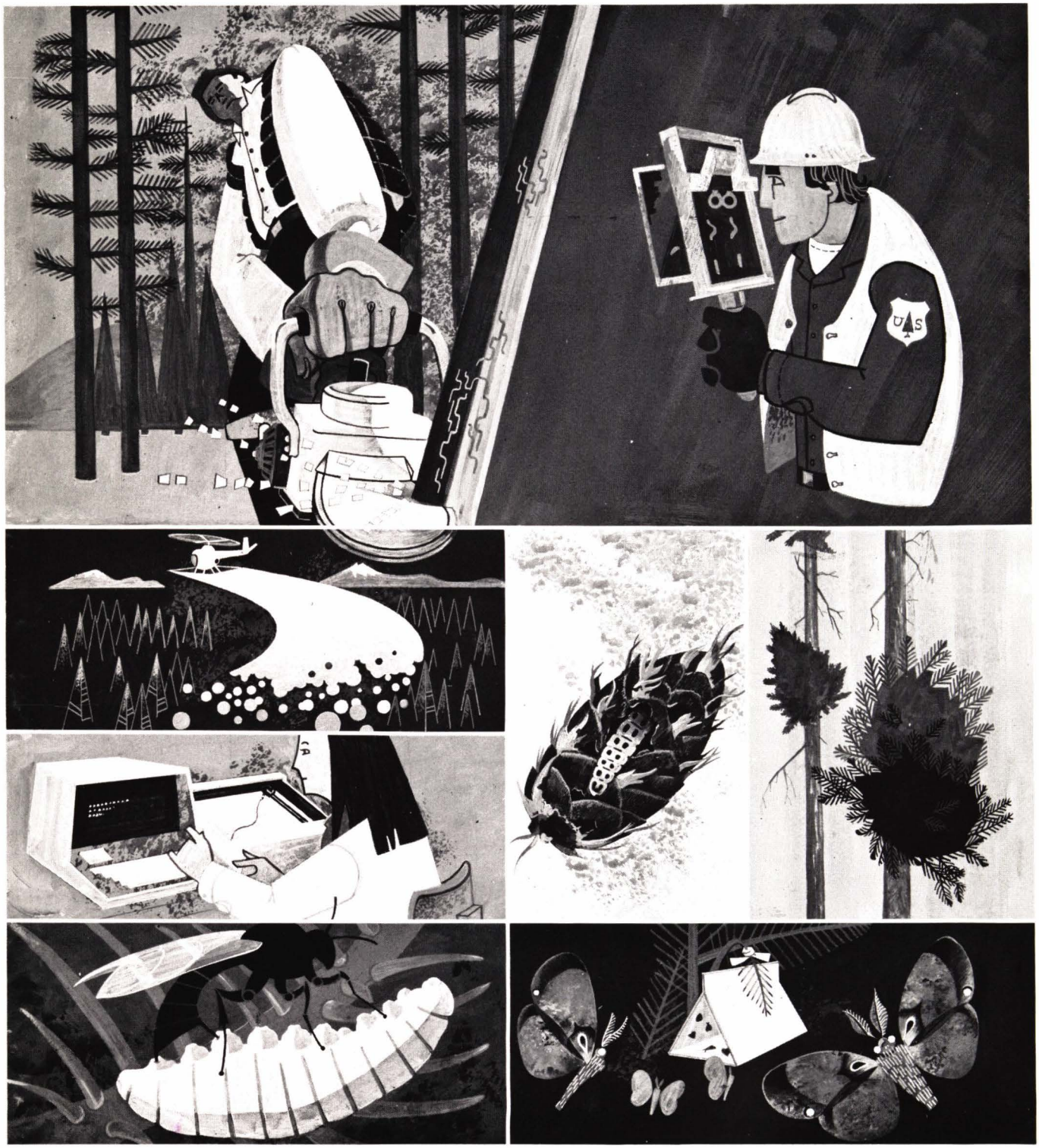
PANORAMIC AERIAL PHOTOGRAPHY FOR ASSESSING FOLIAGE PROTECTION ACHIEVED BY AERIAL SPRAYS DIRECTED AGAINST THE GYPSY MOTH



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PANORAMIC AERIAL PHOTOGRAPHY FOR ASSESSING FOLIAGE PROTECTION ACHIEVED BY AERIAL SPRAYS DIRECTED AGAINST THE GYPSY MOTH

by

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ABSTRACT

Defoliation was classified on high altitude panoramic aerial photos in and around blocks of hardwood forest treated for suppression of gypsy moth, Lymantria dispar L., in central Pennsylvania. Detailed photo interpretation showed differences in defoliation intensity in treated vs surrounding untreated areas in two-thirds of the spray blocks examined. This approach can be used provided that areas of similar forest cover type exist adjacent to the spray block boundaries and that prespray insect population levels are sufficiently high to cause aerially visible defoliation.

An approach for making assessments in spray blocks as part of an area wide defoliation mapping task is suggested. This eliminates possible bias introduced from photo interpreters having a priori knowledge of the exact location of spray block boundaries.

Use of high altitude panoramic aerial photos for assessing effectiveness of treatments in addition to general defoliation mapping increases the cost effectiveness of this photo product.

INTRODUCTION

Color or color-IR aerial photos at large to medium scales (1:4,000 - 1:15,000) have been shown to be effective for assessing foliage protection achieved by aerial application of chemical or microbial insecticides against a number of defoliating forest insects. Foliage protection is assessed by comparing intensity of defoliation in treated areas to that in adjoining areas of similar forest cover type, topography and target insect population density or untreated check plots.

Ciesla, et al. (1971) showed that color-IR photos can be used to assess effectiveness of experimental insecticides tested for suppression of forest tent caterpillar, Malacosoma disstria Hbn., under conditions where traditional pre- and post-spray insect samples cannot be taken. In addition the quality of the aerial application can be assessed (Ciesla, et al. 1971, Abrahamson, et al. 1982). White, et al. (1978) describe a small format camera system for

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obtaining aerial photos of experimental spray blocks. Bennett and Ragenovitch (1982) used data taken from aerial photographs coupled with traditional ground sampling methods to evaluate efficacy of aerial application of the insecticide acephate against pandora moth, Coloradia pandora Blake, a defoliator of western pines.

Recently small scale (nadir scale = 1:30,000) high resolution, panoramic aerial photography has been used to inventory tree mortality caused by mountain pine beetle, Dendroctonus ponderosae Hopk., and facilitate salvage of trees killed by bark beetles (Klein 1982, Dillman and White 1982, Caylor, et al. 1982). Characteristics, advantages and limitations of this photo product are described by Ciesla, et al. (1982) and Liston (1982). In 1981, high altitude panoramic photography obtained over a 2,800 square mile test site in central Pennsylvania demonstrated its feasibility for mapping extensive areas of hardwood defoliation caused by gypsy moth (Ciesla and Acciavatti 1982).

Several states in the northeastern United States infested by gypsy moth, Lymantria dispar L., conduct control programs with chemical and microbial insecticides to provide foliage protection in areas of high value and use. Assessment of the effectiveness of these treatments is presently made by ground surveys of defoliation in a small sample of spray blocks. No attempt is made to assess the amount of defoliation in adjacent stands. The ability to assess effectiveness of these programs from high altitude panoramic aerial photos would provide a more complete post treatment evaluation and would increase the utility and cost effectiveness of this photo product in gypsy moth management programs.

METHODS

DATA SOURCES - Color-IR (SO 131) high altitude panoramic aerial photography obtained over a test site in central Pennsylvania on June 28, 1981 for mapping defoliation by gypsy moth was used for this evaluation. Photographic parameters of this mission are described in detail by Ciesla and Acciavatti (1982).

Areas treated for gypsy moth suppression in Mifflin County, Pennsylvania during 1981 were selected for evaluation. This consisted of 45 irregularly shaped spray blocks ranging in size from 6 to 264 acres. As is typical of gypsy moth control programs in the Northeast, spray blocks consisted of forested communities, scenic corridors, forest recreation sites, and some areas within the general forest. Blocks were treated by helicopter with the insecticide trichlorfon during the period May 21-26, 1981.

Blocks 7, 12, 15, 16, 18 and 22 were not included in the evaluation because they occurred in a portion of Mifflin County where aerial photo coverage was not available. Therefore 39 spray blocks were included in the evaluation (Table 1).

Two methods were used to assess foliage protection in the spray blocks; a defoliation map-spray block overlay and detailed photo interpretation.

Table 1 - Summary of Spray Blocks Included in Foliage Protection Evaluation - Mifflin County, Pennsylvania - 1981 (Data from Pennsylvania Bureau of Forestry)

Block No. 1/	Date Treated	Acres Treated
1	5-22	105
2	5-23	51
3	5-23	24
4	5-23	48
5	5-23	6
6	5-23	9
8	5-23	48
9	5-23	63
10	5-23	27
11	5-26	57
13	5-21/22	51
14	5-21	60
17	5-21	36
19	5-21	34
20	5-21	39
21	5-21	54
23	5-21	30
24	5-21	150
25	5-20/21	201
26	5-20	135
27	5-20	6
28	5-20	33
29	5-20	21
30	5-20	27
31	5-20	144
32	5-26	96
33	5-23	72
34	5-23	48
35	5-23	60
36	5-23	84
37	5-23	66
38	5-23	45
39	5-23	90
40	5-23	33
41	5-23	117
42	5-23	21
43	5-23	63
44	5-23	78
45	5-26	264

1/ Blocks 7, 12, 15, 16, 18 and 22 were not included because photo coverage was not available.

DEFOLIATION MAP - SPRAY BLOCK OVERLAY - Portions of USGS 7 1/2 minute (1:24,000 scale) topographic maps showing locations of spray blocks were provided by the Pennsylvania Bureau of Forestry. These were transferred to the defoliation maps prepared from the original photo interpretation of the central Pennsylvania test site. The maps contained the approximate location of defoliated areas classified into two intensity strata:

> Moderate and Widespread - host type with first noticeable defoliation visible from aerial observation (generally 30-60% defoliation).
>
> Heavy and Widespread - host type with greater than 60% loss of host foliage.

Intensity of defoliation relative to the location of each spray block was used to determine if foliage protection was achieved. The following decision rule was used to determine if the block showed an apparent treatment effect:

> Defoliation in spray block $\geq$ defoliation immediately outside of block - No effect.
>
> Defoliation in spray block $<$ defoliation immediately outside of block - Possible treatment effect.
>
> Blocks surrounded by non-forest or no aerially visible defoliation in spray block or vicinity of block - Inconclusive.

DETAILED PHOTO INTERPRETATION - Each spray block occurring within $\pm 40°$ of nadir was located on the aerial photographs. Vegetation type and damage intensity was interpreted monoscopically on a portable light table and classified in and around each spray block as follows:

> NF - Non-forest; fields, meadows, quarries, water, etc.
> C - Plantation of coniferous trees, i.e., Scots pine, eastern white pine, Norway spruce, etc.
> O - Hardwood forest - no aerially visible defoliation.
> M - Hardwood forest - moderate and widespread defoliation.
> H - Hardwood forest - heavy and widespread defoliation.

A detailed defoliation map was prepared showing location of vegetation type classes relative to the each spray block (Figure 1). In addition a narrative description of defoliation intensity relative to the boundaries of the spray blocks was prepared (Table 2).

RESULTS

The defoliation map/spray block overlay indicated that 7 of the 39 spray blocks (17.9%) showed some differences in damage intensity when defoliation within the block was compared to surrounding untreated areas. Of the remaining 32 blocks, 11 occurred in areas either completely surrounded by fields, cropland or other non-forest type or where no visible hardwood

Table 2 - Summary of Narrative Description of Photo Interpretation of Blocks Treated for Control of Gypsy Moth - Mifflin County, Pennsylvania - 1981

Block No.	Description	Treatment Effect (Y=yes N=No I=Inconclusive)
1	Areas of moderate and heavy defoliation occur to north and west of block. Most of forest area within block has no visible defoliation. A small area of heavy defoliation extends into south block from ridge parallel to Furnace Run. Low lying area to east of block has no visible defoliation.	Y
2	Moderate and heavy defoliation occur in forest area west and south of block. Scattered patches of moderate defoliation occur in lower lying areas east of block. Forest area within block is free from visible defoliation.	Y
3	No visible defoliation within block. Scattered patches of light to moderate defoliation occur in forest surrounding block.	Y
4	Long narrow strip of heavy defoliation occurs west of block. Boundary of moderate defoliation coincides roughly with west edge of block. Large area of light to moderate defoliation occurs in woodlot southeast of block. Defoliation boundary coincides with southeast boundary of block. No visible defoliation in block.	Y
5	No visible defoliation in block. Areas of moderate and heavy defoliation surround block to northeast and west. South boundary of block is an open field.	Y
6	Small spray block has no visible defoliation while surrounding stands have moderate defoliation. There is a sharp line of demarkation on south boundary of block.	Y

Table 2 (continued)

Block No.	Description	Treatment Effect
8	Northwest boundary of block coincides with boundary of heavy defoliation. No visible defoliation in block. Areas to south and west of block are non-forest.	Y
9	No visible defoliation in block except for northwest and southwest corners. Heavy defoliation occurs in forested areas surrounding block.	Y
10	No visible defoliation in spray block except southwest corner. Defoliation is moderate north of block and heavy southwest of block. There is a possible zone of spray drift along western boundary of block.	Y
11	Block is on crest of a ridge. An area of moderate defoliation coincides roughly with block boundary. This area is almost entirely surrounded by heavy defoliation. Moderate defoliation extends beyond west boundary of block into creek bottom.	Y
13	Southern third of block has moderate defoliation. Remainder has no visible defoliation.	N
14	South edge of block coincides with boundary of moderate defoliation. Area within block has no visible defoliation.	Y
17	Moderate defoliation occurs along southwest and east boundaries of block. North of block is non-forest. Area within block has no visible defoliation.	Y
19	Moderate defoliation occurs on ridge crests just beyond block boundary. Eastern half of block has no visible defoliation. Western half of block has moderate defoliation.	Y
20	Strip of light defoliation exists on ridge that coincides with northern edge of block boundary. Area within block has no visible defoliation.	Y
21	Northern edge of block coincides with boundary of moderate defoliation. Area within block has no visible defoliation.	Y

Table 2 (continued)

Block No.	Description	Treatment Effect
23	No defoliation in block or in forested areas in immediate vicinity.	I
24	Area to north of block has moderate defoliation. Area within block has no visible defoliation. Area to south of block is non-forest.	Y
25	Area northwest of block has moderate defoliation. Scattered individual trees within block have partial defoliation.	N
26	Western edge of block coincides with an abrupt end of two polygons of moderate defoliation on two parallel ridges. Scattered moderate defoliation occurs on trees near block center and on ridge at north end of of block.	Y
27	Small group of open grown trees make up spray block. No visible defoliation within block. Moderate defoliation occurs in forest area immediately to north of block. Area south of block is non-forest.	Y
28	Areas northwest and southwest of spray block have moderate defoliation.	Y
29, 30	No defoliation in block or in vicinity of block.	I
31	Heavy defoliation begins north of block. Area within block does not have visible defoliation. Low elevation hardwood stands south of block are also free of defoliation.	Y
32	Area north of block has heavy defoliation. Area west of block has moderate defoliation. No visible defoliation in block or forest area extending into Coopers Gap.	Y
33	Scattered defoliation occurs north of spray block in open stand. South edge of block coincides with Juniata River. No visible defoliation in block.	Y
34	Boundaries of moderate defoliation coincide with south and east boundaries of block. No visible defoliation in block.	Y

Table 2 (continued)

Block No.	Description	Treatment Effect
35	No visible defoliation in block or in vicinity of block.	I
36	Portion of southern edge of block conforms to boundary of moderate defoliation. No visible defoliation in block.	Y
37, 38, 39, 40, 41, 42, 43	No visible defoliation in block or in vicinity of block.	I
44	No visible defoliation in block. Heavy defoliation begins east of block and on ridge above block. Heavy defoliation begins again on Little Mountain west of US 322.	Y
45	Plot follows Lingle Creek and road parallel to creek. Areas to north and south of block have heavy defoliation. Heavy defoliation extends to edge of creek immediately west of block boundary.	Y

Table 3 - Summary of Foliage Protection Assessment Using a Defoliation Map Spray Block Overlay - Mifflin County, Pennsylvania - 1981

Apparent Treatment Effect	Yes	No	Inconclusive
Blocks occurring in this class	1, 2, 8, 9, 10, 21, 44	3, 4, 5, 6, 11, 13, 14, 17, 19, 20, 24, 25, 26, 27, 28, 31, 32, 33, 34, 36, 45	23, 29, 30, 35, 37, 38, 39, 40, 41, 42, 43
Total blocks	7	21	11

Table 4 - Summary of Foliage Protection Assessment from Detailed Photo Interpretation of Spray Block and Surrounding Hardwood Forest Mifflin County, Pennsylvania - 1981

Apparent Treatment Effect	Yes	No	Inconclusive
Blocks occurring in this class	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 14, 17, 19, 20, 21, 24, 26, 27, 28, 31, 32, 33, 34, 36, 44, 45	13, 15	23, 29, 30, 35, 37, 38, 39, 40, 41, 42, 43
Total	26	2	11

defoliation occurred either in the block or in surrounding stands of hardwoods. These spray blocks did not lend themselves to this type of an evaluation. Defoliation appeared to occur more or less independently of the spray block boundaries in the remaining 21 blocks (Table 3).

Detailed photo interpretation revealed 26 spray blocks (66.7%) with some apparent treatment effect (Table 4). This was significantly higher than the defoliation map/spray block overlay (Chi square=23.6 @ 1 d.f; reject H_0:PI=Overlay in favor of H_1:PI> overlay at the .05 level of probability). Careful re-examination of each spray block and the area immediately surrounding the block revealed a number of instances where boundaries of defoliated areas roughly coincided with spray block boundaries (Table 2, Figures 1 & 2). Often a sharp line of demarkation was observed with heavy defoliation occurring just beyond the spray block and the foliage in the spray block with no visible damage. In other cases additional areas of localized moderate defoliation were detected that were not previously mapped. This was especially true in areas from $\pm$20 to 40° of nadir where image distortion and some atmospheric haze tend to make photo interpretation more difficult. In three instances, blocks 4, 11 and 44, significant errors in location of defoliation boundaries were made on the original interpretation of the panoramic photography. When defoliation boundaries were replotted, an apparent treatment effect could be seen.

Ground data taken by the Pennsylvania Bureau of Forestry on six of the spray blocks (Blocks 17, 19, 20, 21, 31 and 45) show a range of 5 to 15% defoliation. This is well below the 30% threshold of aerially visible defoliation. The aerial photo interpretation of these blocks is in agreement with existing ground data.

DISCUSSION AND CONCLUSIONS

High altitude color-IR panoramic aerial photographs can be used to assess hardwood foliage protection achieved by aerial sprays directed against gypsy moth provided that:

1. Surrounding areas of the same forest cover type occur beyond the spray block boundaries; AND

2. Prior to treatment both sites contain similar populations of the target pest; AND

3. Populations of the target pest are capable of causing aerially visible defoliation (approximately 30% or more of the foliage removed).

In this evaluation, approximately one-fourth of the spray blocks did not meet these criteria. These blocks occurred in wooded residential areas surrounded on three or more sides by land cover types other than hardwood forest or did not contain sufficiently high populations of gypsy moth to cause aerially visible defoliation.

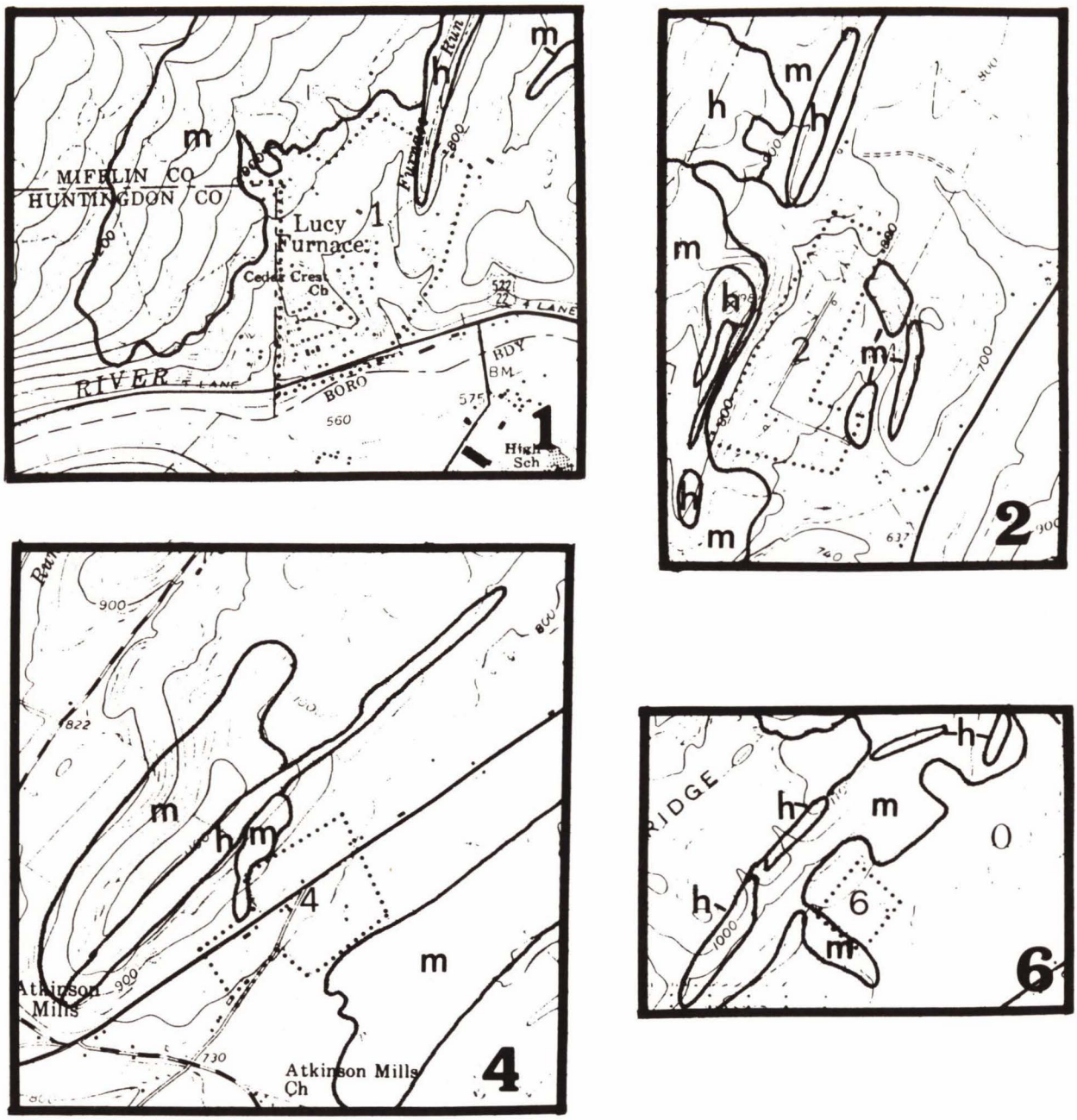

Figure 1 - Hardwood defoliation relative to Blocks 1, 2, 4 and 6, Mifflin County, Pennsylvania, 1981, treated for suppression of gypsy moth infestation. Dotted lines represent spray block boundaries; m = moderate defoliation; h = heavy defoliation. Approximate scale = 1:24,000.

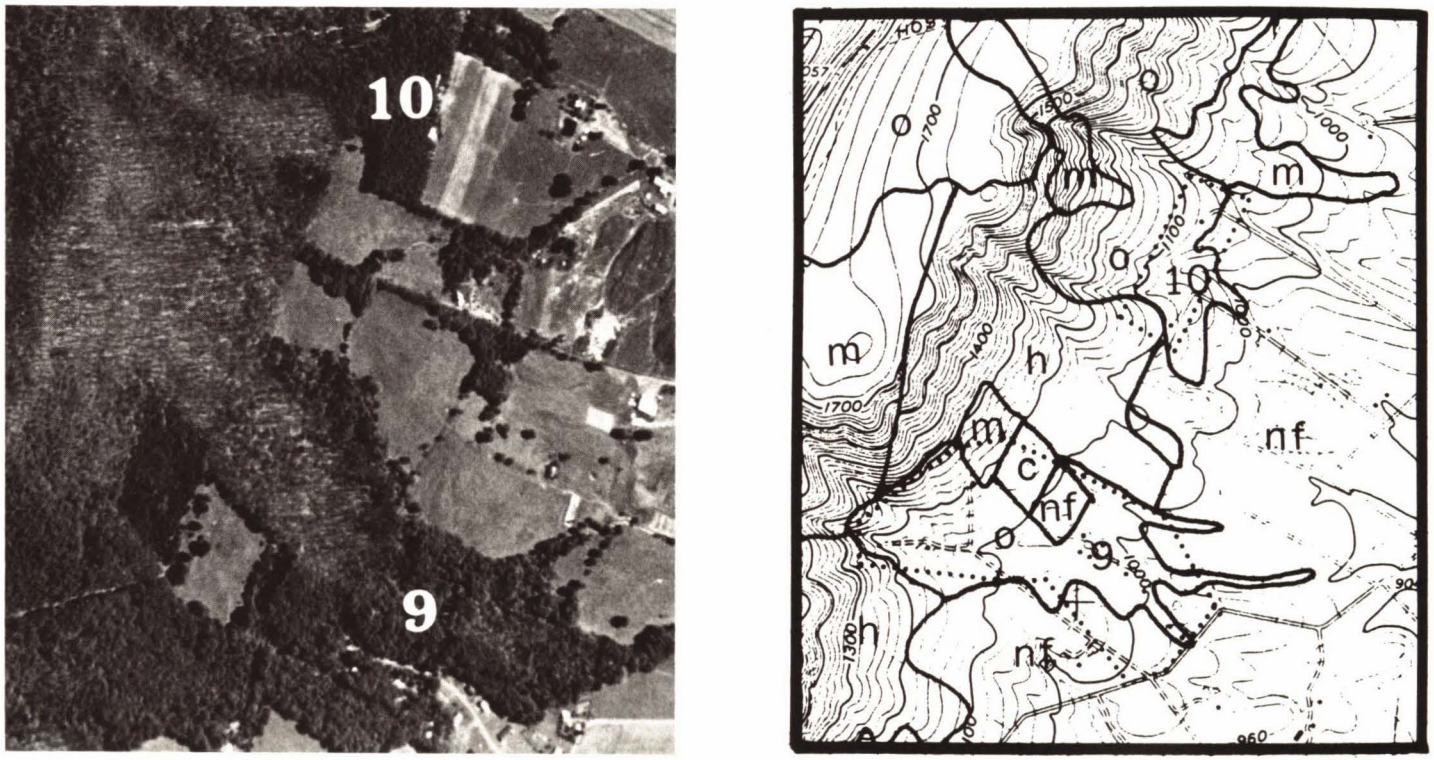

Figure 2 - Black and white print of color-IR panoramic photo of Blocks 9 and 10, Mifflin County, Pennsylvania, 1981, treated for suppression of gypsy moth infestations and accompanying defoliation map. Dotted lines represent spray block boundary; o = no visible defoliation; m = moderate defoliation; h = heavy defoliation; c = conifer plantation; nf = non-forest. Approximate scale = 1:24,000.

In previous work (Abrahamson, et al. 1982, Bennett and Ragenovitch 1982, Ciesla, et al. 1971, and White, et al. 1978) assessments of foliage protection were made as part of field experiments or pilot control projects of promising new insecticides. Under these conditions, rectangular or square spray blocks are typically established. These are usually surrounded by stands of a similar forest cover type on three or more sides. If the insecticide is effective in protecting foliage, a geometric block of protected foliage, surrounded by areas of damaged foliage is resolved on the aerial photo.

In operational spray programs, such as are carried out in Pennsylvania and other northeastern states for control of gypsy moth, spray blocks are typically irregular. They conform to boundaries of individual properties, public parks, forested subdivisions, or however the resource being protected is distributed. In addition, natural variations in gypsy moth populations relative to stand age species composition, topographic features or land use patterns often result in considerable variation in intensity of defoliation. This variation is usually independent of direct control efforts. These factors significantly increase the complexity of the foliage protection assessment task.

The fact that errors in defoliation boundaries as established during the original photo interpretation of the Pennsylvania test site were detected may cast some doubt as to the quality of the original defoliation mapping. One must keep in mind however, that the original defoliation classification and map transfer was done fairly rapidly. Each photo interpreter attempted to complete 15 photo frames per day. At this rate it is likely that some errors in locating defoliation boundaries would occur. While this standard of photo interpretation and map transfer is quite adequate for general defoliation mapping, it is not suitable for assessment of foliage protection in treated areas.

On the other hand, the fact that a photo interpreter has a priori knowledge of the exact location of spray block boundaries may introduce bias into the classification of vegetation damage and cast doubt on the validity of the assessment. An acceptable compromise might be to mark general areas within which one or more spray blocks are located on USGS 7 1/2 topographic maps before general defoliation mapping is done. This will alert photo interpreters to the need for more careful interpretation within these areas without their having knowledge of the exact location of spray blocks.

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